Advanced Space Propulsion Workshop 2001
NASA
George C. Marshall Space Flight Center
Materials, Processes and Manufacturing Department
Environmental Effects Group

LIFE CYCLE TESTS ON A HOLLOW CATHODE BASED PLASMA CONTACTOR

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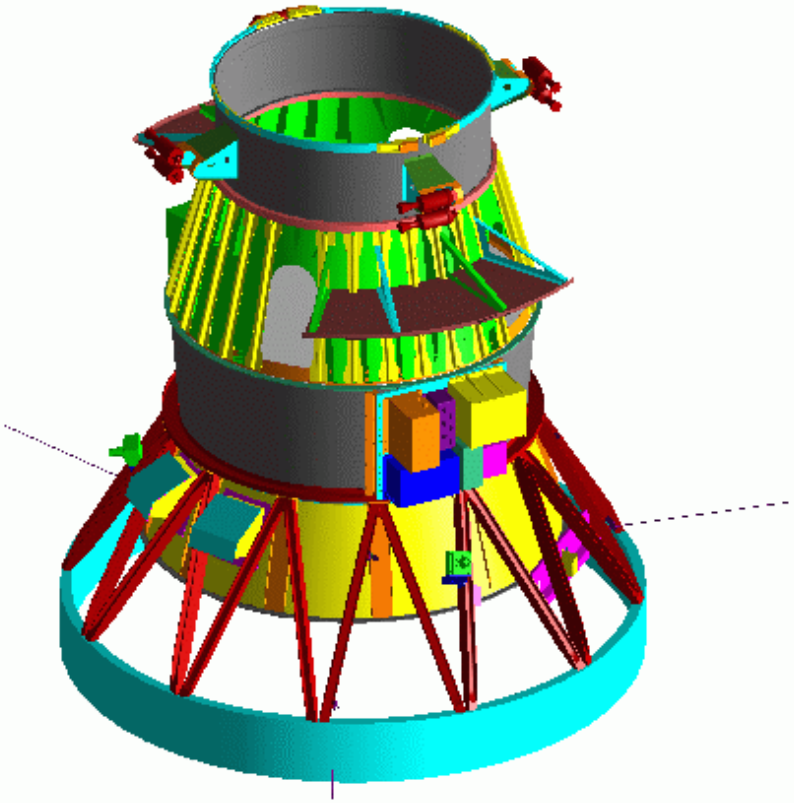
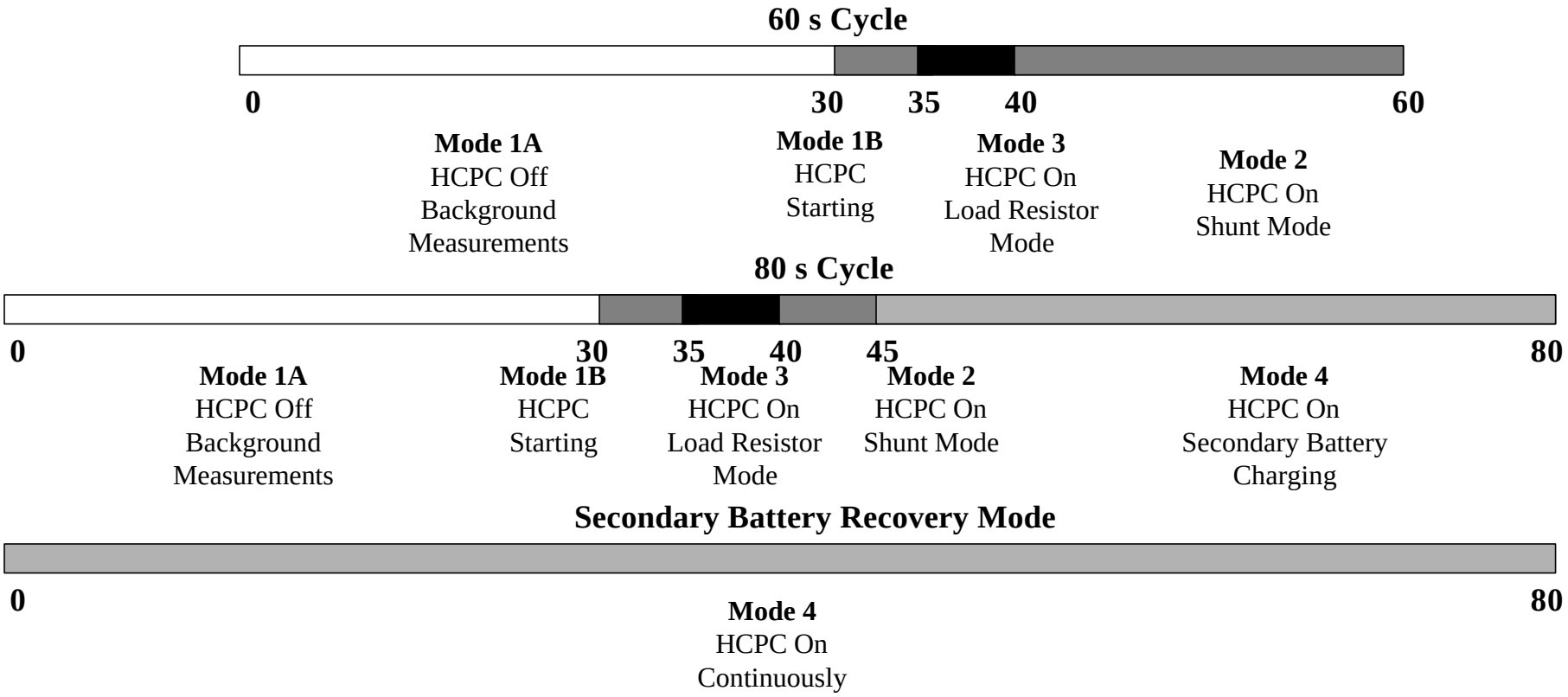
ProSEDS Flight Experiment

- **Secondary Payload Attached to Delta II Second Stage.**
- **Demonstrate Propellant-less Propulsion Technology by De-orbiting the 2nd Stage**
  - In ~ 2 Weeks As Opposed to 6 Months
- **Tether Characteristics**
  - 5 Km Long Semi-bare Aluminum Tether
  - 10 Km Spectra (UHMWPE) Ballast Tether
  - Maximum Estimated Potential, 1560 V.
- **Current Flow Through Tether Produced Using a Hollow Cathode Based Plasma Contactor.**
- **Hollow Cathode Plasma Contactor (HCPC) Designed and Built by Electric Propulsion Laboratory (EPL) Monument, CO,**



ProSEDS Standard Operating Modes



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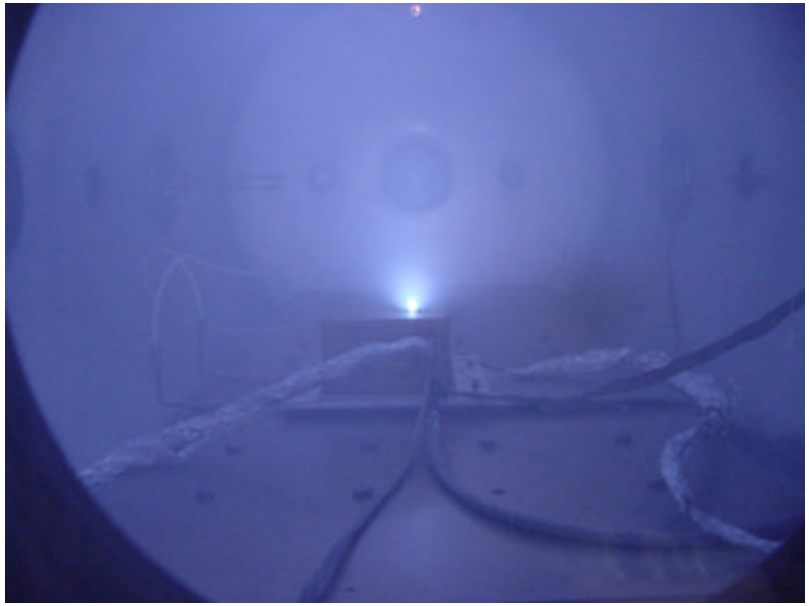
HCPC Specs for ProSEDS

- Developed by Electric Propulsion Laboratory (EPL)
- HCPC Uses 250 Series Hollow Cathode (OD 0.25”)
- 2 Sccm Xenon Flowrate
- 1 Hr on Orbit Conditioning Cycle (50 W)
- 150 Sec First Time Cold Start (55 W)
- 0.1 to 10 A Electron Current Emission (36 W to 20 W)



ProSEDS HCPC Calculated Cycles During Mission

- **Primary Battery**
  - First Seven Orbits on Primary Battery
    - ProSEDS Employs the 60 S Cycle
    - HCPC on 50% of Time
    - 630 Cycles During This Period
- **Secondary Battery**
  - Remainder of Life From Seven Orbits for 12 Days
    - ProSEDS Employs the 80 S Cycle, 70 % of Time
    - ProSEDS Will Be in Secondary Battery Recovery, 30% With No Cycling
    - HCPC Cycling 70% of Time
    - Total Cycles for This Period 8,741 Cycles
- **Total Cycles for ProSEDS Mission**
    - Total Cycles **9,371 Cycles**
- **Test HCPC Unit for 10,000 Cycles**

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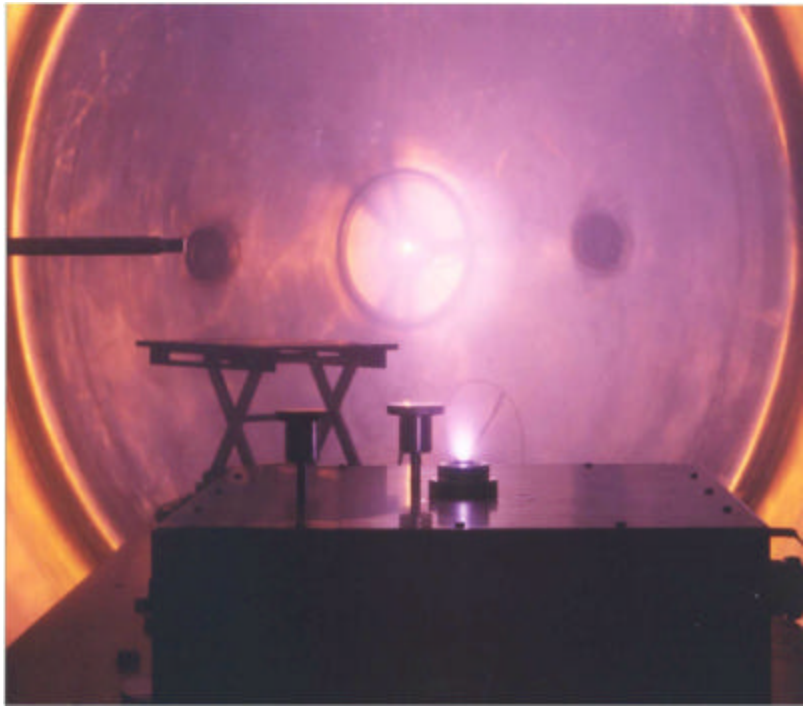
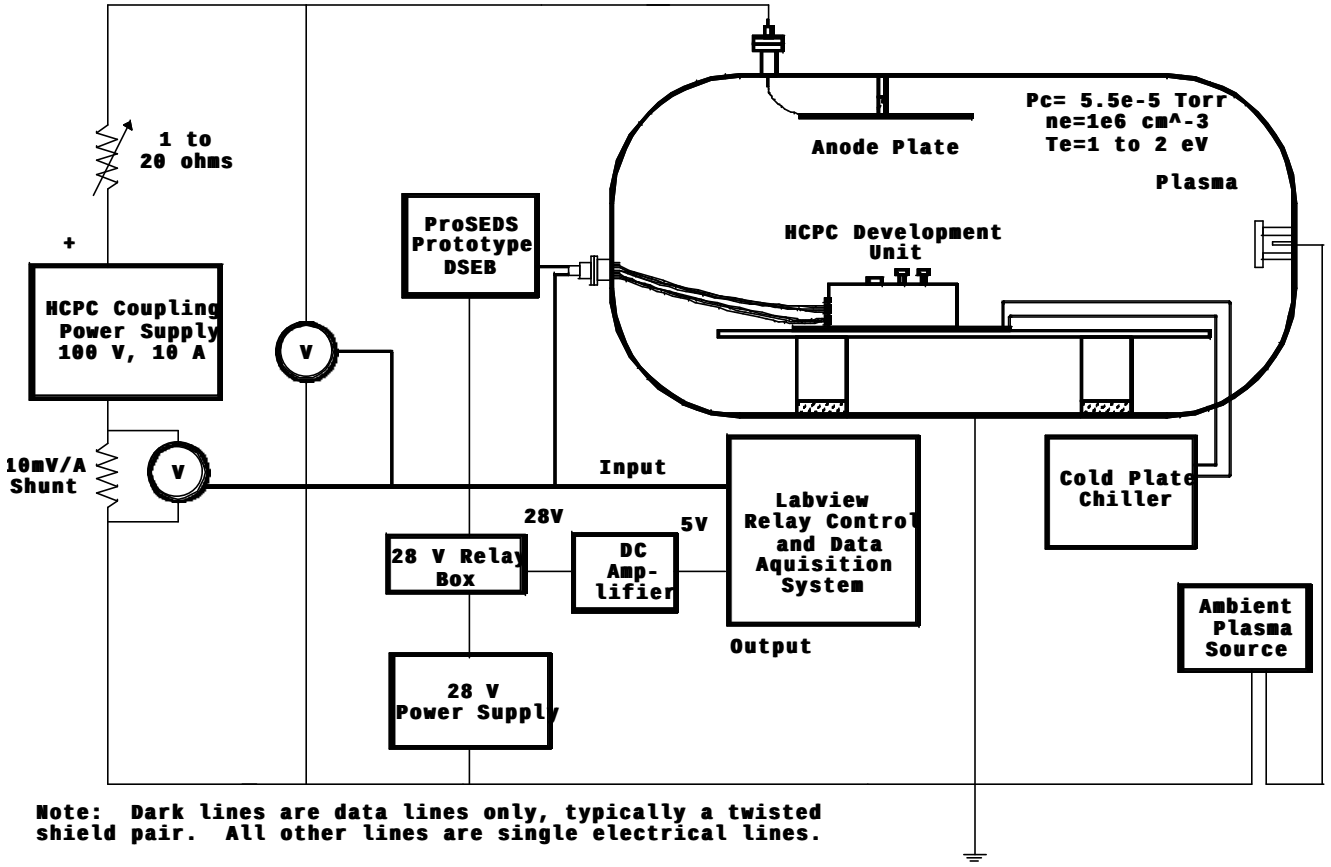
HCPC Engineering Test Pallet Description

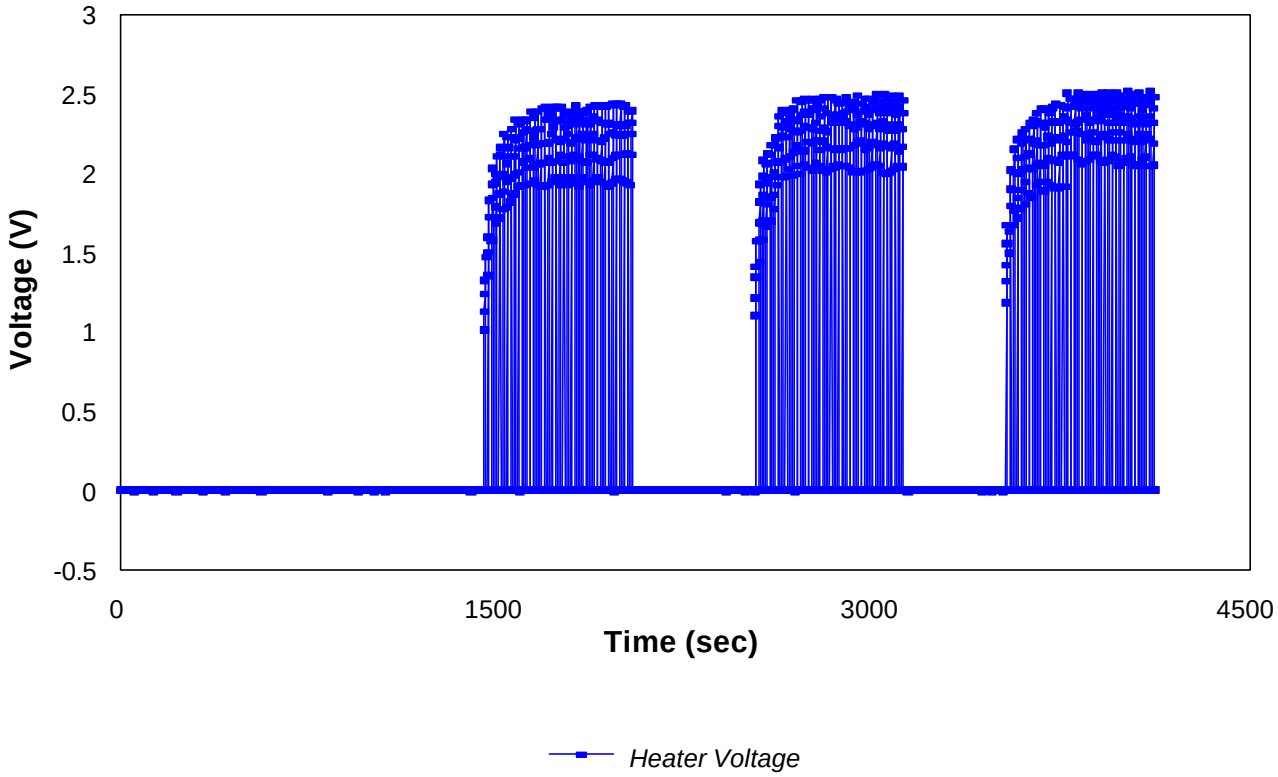
- **HCPC Engineering Test Pallet Hollow Cathode From the Same Lot As Flight Unit**
  - 0.25” OD
- **Electrical System**
  - DC/DC Converters Where the Same As the Flight Unit
  - Thermistors Were Replaced With Resistors
- **Gas System**
  - Gas Tank Same Volume but Made of SS. Flight Version Made of Aluminum.
  - Gas Regulator Same As Flight Version.
  - Gas Solenoid Valve Same As Flight Version
  - Main Gas Valve Is a Hand Valve When in Flight the Valve Is Latch Valve.
- **Enclosure Twice As Large As Flight Unit**



HCPC Cycle Test Configuration



HCPC Conditioning Cycle



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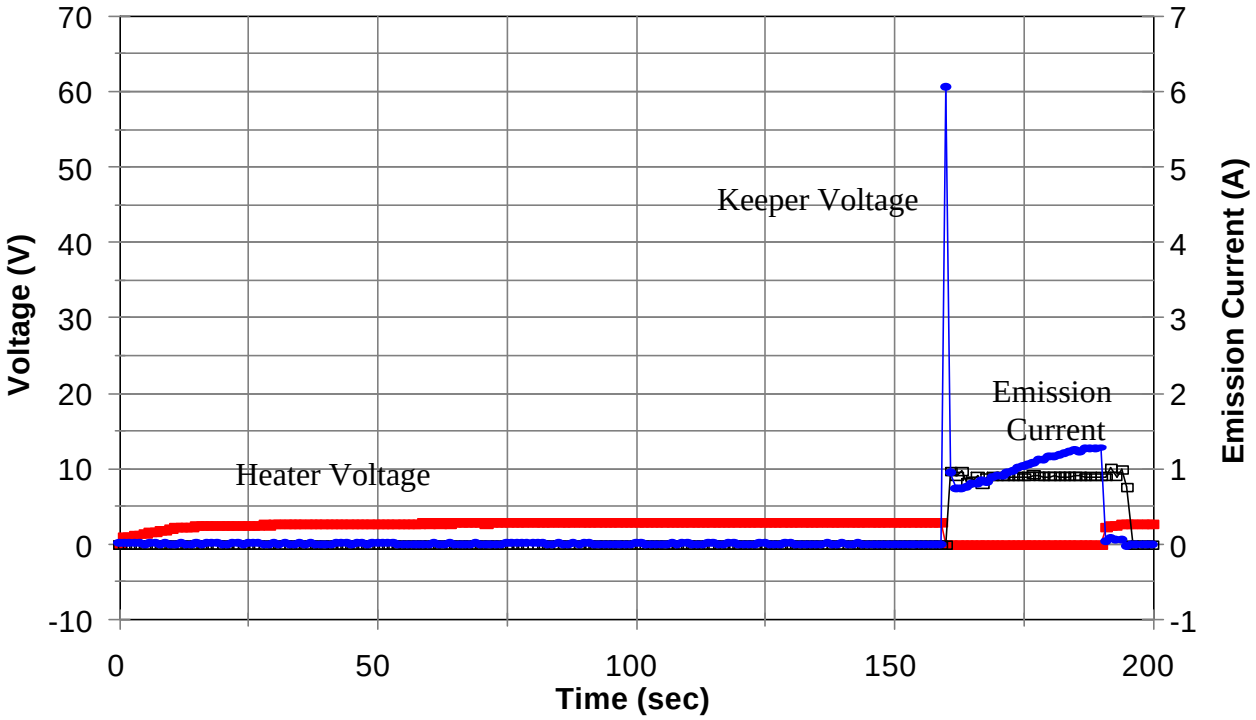
Typical First Time Cold Start



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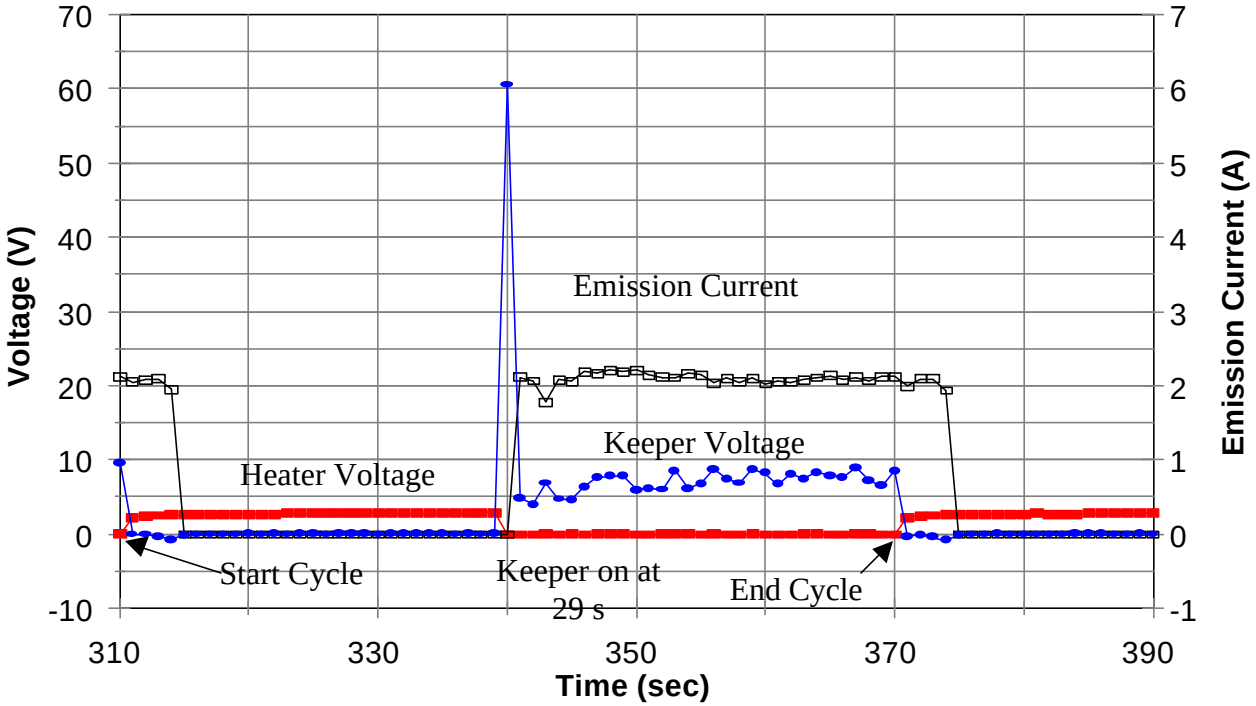
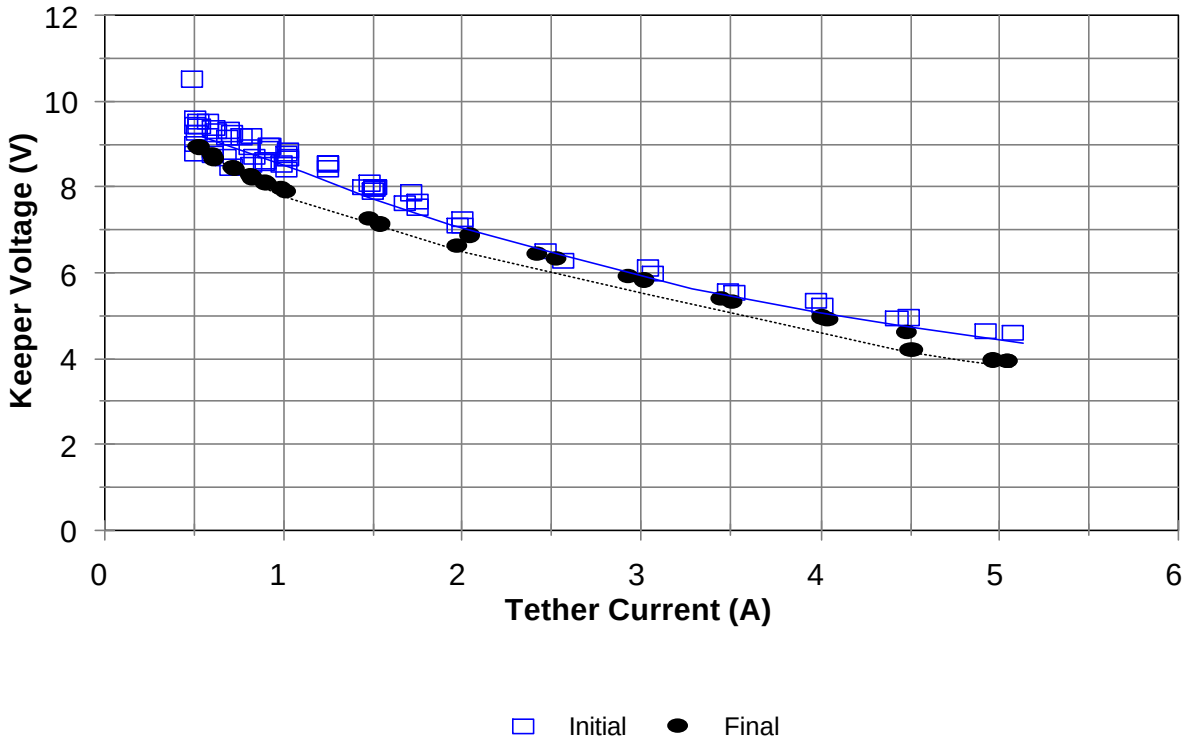
Typical 60 s Cycle



HCPC Life Test

Keeper Voltage



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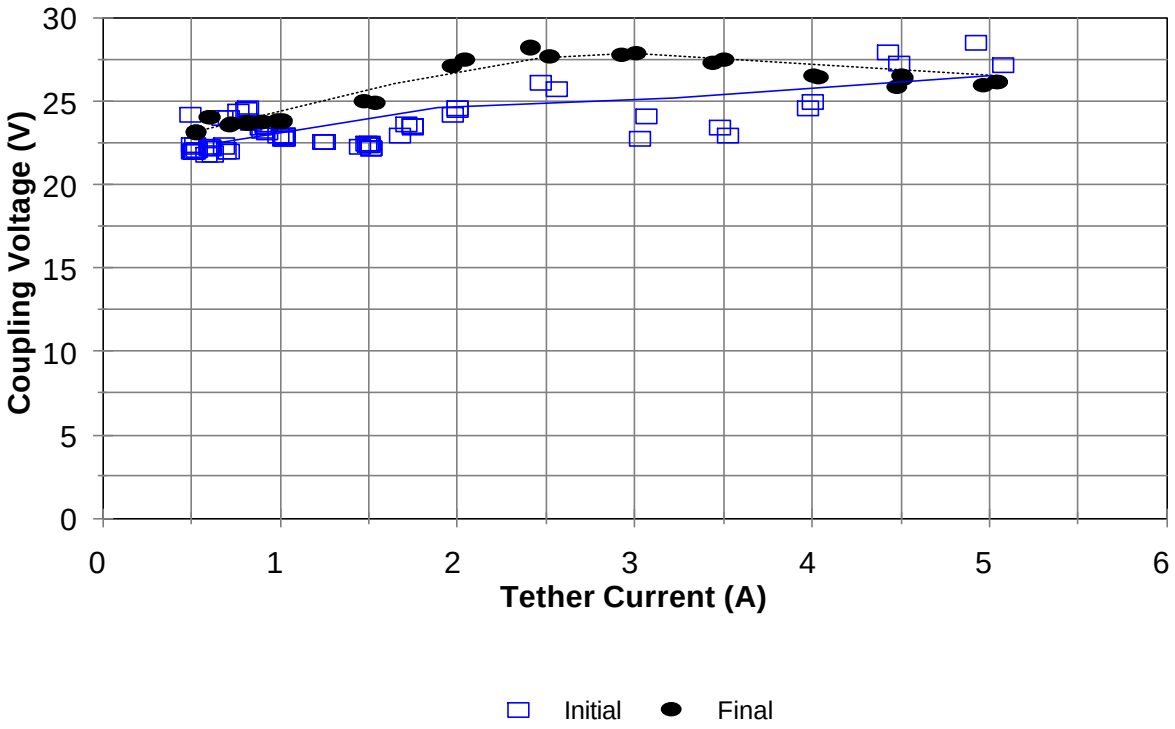
HCPC Life Test

Coupling Voltage



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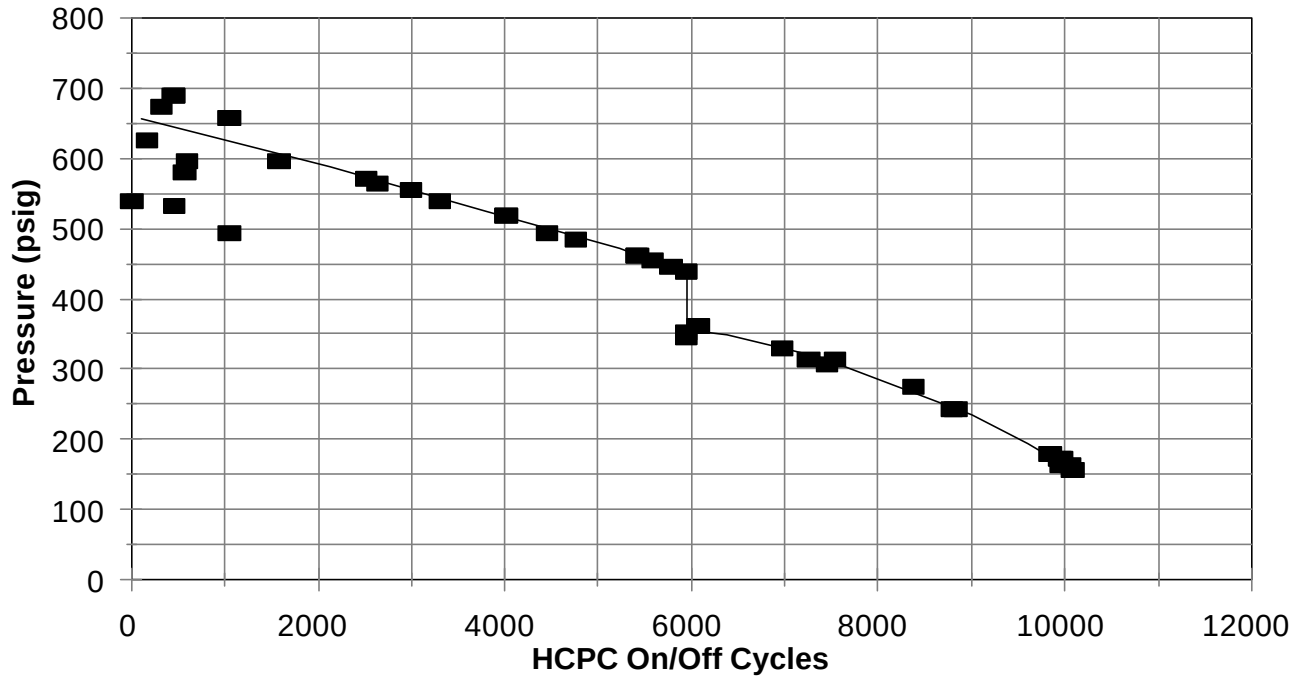
HCPC Life Test

Xenon Pressure in Tank



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HCPC Cycle Test Results

- **Began Test on Jan. 12, 2000 and Ended Test on Jan. 21, 2000.**
- **HCPC Engineering Test Pallet Completed 10,095 Cycles.**
- **Measured a Slight Decrease Between Initial and Final Keeper Voltage Data Over the Range of Emission Currents**
- **Encountered Problems With Keeping System Cool Early in the Test.**
  - HCPC Has A Temperature Limit on the DC/DC Converters. This Temperature Was Exceeded Early in the Test Because the Thermal Interface Between HCPC and Cooling Plate Was Not Sufficient.